Completing the equations

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The Maxwellians. By Bruce J. Hunt. *Cornell University Press: 1991. Pp. 266. $34.95.*

THE history of British electromagnetic theory after James Clerk Maxwell has, until recently, attracted little attention from historians of science. Received histories of physics tend to be rather linear, pausing in Britain in the nineteenth century just long enough to chronicle the contributions of Michael Faraday and Maxwell, before moving on to Germany in anticipation of relativity and quantum theory. In these histories, Maxwell is most remembered for his fundamental equations of electromagnetism and his prediction of the existence of electromagnetic waves. But, as Bruce Hunt notes, Maxwell's fullest statement of his theory (set down in his *Treatise on Electricity and Magnetism* of 1873) contains neither the four famous 'Maxwell's equations' nor even a hint at how electromagnetic waves might be produced or detected. In *The Maxwellians*, Hunt sets out to describe how, following Maxwell's premature death in 1879, what would become known as 'Maxwell's theory' was developed in late-Victorian Britain.

Hunt's account of the emergence of electromagnetic field theory is refreshingly different from those offered by other authors. He neither focuses excessively on the achievement of a single individual nor offers a general survey of contributors. Rather, he draws on a wealth of unpublished manuscripts and correspondence to chart the interaction between three physicists, George FitzGerald, Oliver Lodge and Oliver Heaviside, who were gradually drawn together during the 1880s by a common interest in Maxwell's *Treatise*. Hunt argues that it was due largely to the efforts of these men — the 'Maxwellians', as he appropriately dubs them — that a Maxwellian orthodoxy emerged in Britain. It was, for example, FitzGerald who turned Maxwell's brief remarks on the electromagnetic theory of light into a comprehensive account of optical reflection and refraction. Similarly, it was Heaviside who recast the maze of analysis in Maxwell's *Treatise* into the four powerful vector equations associated with 'Maxwell's theory', thereby asserting the primacy of fields of force (rather than charges and currents) in Maxwellian electromagnetics.

Hunt's insistence on the collaborative nature of the Maxwellian enterprise does not prevent him from giving perceptive biographical accounts of the main characters and, crucially, investigating the origin of their interest in Maxwell's extraordinary book. Indeed, their notable differences of circumstance, ability and temperament, made obvious by comparison of their biographies, reinforces the need for an explanation of how these men's different theoretical interests eventually blended into a common orthodoxy. Hunt argues that a consensus was achieved (albeit relatively briefly) through personal contact and intense correspondence. In this context, Hunt also makes effective use of another main theme of his book — the impetus and material foundation given to the Maxwellian research programme by the burgeoning electrotechnology industry. Lodge and Heaviside, for example, found their first important point of common theoretical interest in their respective attempts to understand the workings of the submarine telegraph and the lightning conductor.

It is impossible here to do justice to Hunt's rich and meticulously documented study, but some highlights are especially worthy of note. For example, Lodge was apparently the first physicist to propose that electromagnetic radiation could be artificially generated, and to design a practiical apparatus for the purpose. Hunt discusses Lodge's early correspondence with FitzGerald on this matter and describes how FitzGerald threw Lodge off the scent by showing (using Maxwell's own equations) that it was impossible to generate electromagnetic radiation artificially. FitzGerald eventually realized his error and Lodge subsequently came very close to becoming the first physicist to demonstrate the existence of electromagnetic waves in free space.

Hunt's story reaches its climax at the momentous 1888 meeting of the British Association in Bath. It was here that FitzGerald made the sensational announcement that the German physicist Heinrich Hertz had succeeded in generating and detecting electromagnetic waves. The widespread excitement produced by Hertz's experiments brought Maxwell's *Treatise* to the fore in physics and further cemented the growing friendship between its leading British interpreters. During the six years that followed — a period referred to by Hunt as the "Maxwellian heyday" — FitzGerald, Lodge and Heaviside worked in close collaboration to popularize and establish Maxwellian electromagnetic theory. One of the many pieces of Maxwellian physics from this period discussed by Hunt is the now infamous 'contraction hypothesis' proposed by FitzGerald in 1889 to account for the null result of the Michelson–Morley ether-drift experiment. The sensitive documentation of this much abused episode in the history of physics is one of the high points of the book, and should finally lay to rest discussion of the influence of this hypothesis in Einstein's subsequent work on relativity.

The Maxwellians is a remarkable achievement for several reasons. First, Hunt is completely familiar with the enormous archive (correspondence and manuscripts) of the Maxwellians; yet he manages to do justice to this literature without overly frequent, or overly long, quotation from his sources. Second, the book is exemplary of the recent trend among historians of science towards placing scientific achievements in a broader historical context. As Hunt makes clear, Maxwellian electromagnetic theory was intimately linked to the Victorian culture from which it sprang and cannot be understood in isolation. Finally, and perhaps most impressively, Hunt combines the highest level of professional historical scholarship with a narrative that is lively and compelling throughout. The only technical material over which a reader without a degree in physical sciences might stumble (Heaviside's route to 'Maxwell's equations') is conveniently relegated to an appendix. These considerable virtues make the book compulsory reading for the professional historian of modern science, and invaluable (and very welcome) as a teaching aid for students working in the field. Anyone interested in the history of physics or electrical engineering will surely find it fascinating. ☐

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